T2

15

PROPOSAL FOR A STUDY AND FABRICATION OF SPATIAL FILTERS

A prime objective in the development of a coherent photographic enlarger is the provision for spatial filtering in a transform plane. (Ref. 1) Accordingly, the coherent enlarger presently completed is equipped for spatial filtering, and one filter is supplied with the instrument.

In providing the facility for spatial filtering it was anticipated that additional filters would be fabricated and used in various photographic processes to enhance the utility of the instrument. The [redacted] would welcome an opportunity to carry out a program of investigation on spatial filtering as applied to the coherent enlarger, and supply a complement of suitable filters.

STAT

Present Filtering Provisions

Since the present enlarger contract calls for the provision of only one filter, the type chosen is one considered to have the greatest general utility. This is a graduated filter having a gaussian density variation calculated to accentuate high frequency contrast in such manner as to compensate for transfer function loss occurring in an original photograph. In making this filter, two widely differing means of fabrication were attempted. One of these, a photographic process, resulted in the filter presently furnished with the enlarger. This filter makes use of a special, very fine grain film, on which the required density gradient is produced by an exposure process developed in the Perkin-Elmer Research Department.

The filter in the form supplied is cemented between accurately polished glass plates having anti-reflection coatings.

The alternate method attempted was one based on a thin layer of dyed liquid contained in a cavity between glass plates (Ref.2). This construction aimed at a maximum uniformity of optical path through the filter and consequent freedom from wave front deformation. A fairly successful filter of this type has been experimentally constructed, but fabrication difficulties prevented supplying one of this type with the prototype enlarger.

Statement Of Work

We propose to fabricate at least three filters:

1. A gaussian with approximately 10% axial transmittance.

2. A non-rotationally symmetric filter to correct for small amount of linear image motion.

3. A filter utilizing photochromic glass or film which would be "self adjusting" to the scene's own spectrum.

These filters will be tested on the Prototype Coherent Enlarger and Spatial Filter instrument using suitable scene photography.

Ref. 1 - M.D. Rosenau - "Proposal for Prototype Coherent Light Enlarger and Spatial Filter" P.E. Eng. Report No. 7354.

Ref. 2 - W.E. O'Brien - Technical Memorandum WEO'B-101 [redacted]

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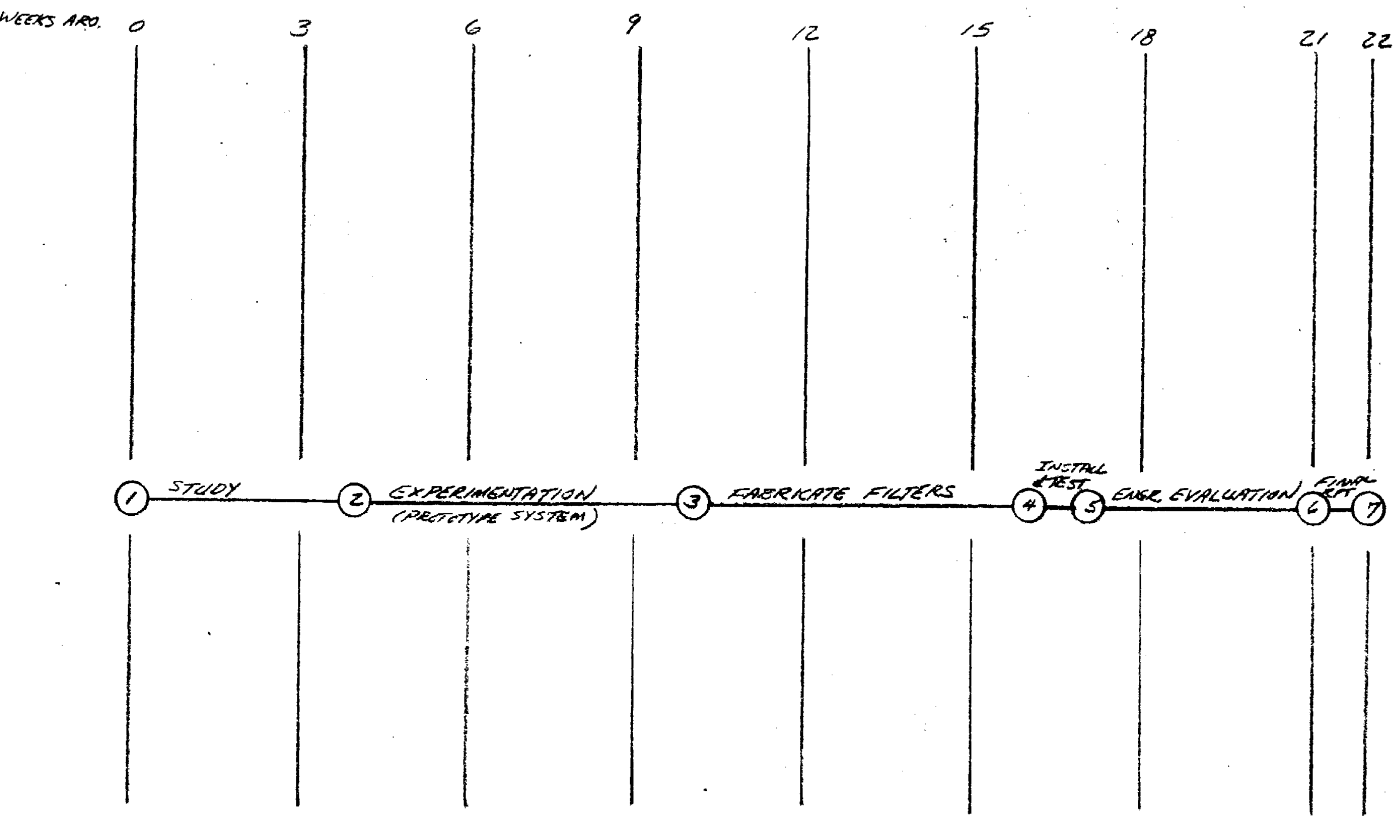
SPATIAL FILTERS



KEY:
○ EVENTS (MILESTONES)
→ WORK FLOW

T3

PROPOSAL FOR DEVELOPMENT OF MEANS FOR DIFFRACTION CONTROL IN A COHERENT ENLARGER

Introduction

In the proposal for a coherent enlarger, embodied in the [redacted] certain possible sources of difficulty were discussed, as well as suggested measures for their control. During the construction of the prototype enlarger and in the accompanying experimental work, these difficulties have in general been effectively dealt with as intended and do not threaten the optical performance of the instrument.

There exists however an outstanding exception to the above, in the form of diffraction patterns in the image due to minute artifacts (as well as any dust particles) in the optical system. This artifact diffraction problem which was observed from the start of the enlarger experimental program is extremely persistant and difficult to control. During the enlarger breadboard work, considerable time was spent in study of this diffraction effect, and control measures were developed which greatly reduce the severity of the resulting interference in the photographic image. However, development work remains to be done on various aspects of the problem, as for example, means for reducing the exposure requirements, and in optimising the condenser optics.

Nature of the Problem

If a minute particle is present in an optical system using coherent light a diffraction pattern corresponding to the particle will appear in the image plane. This pattern results from a convolution of the optical system aperture with the particle diffraction and somewhat resembles an Airy pattern. The prominence of the pattern is in general independent of the size of the particle, which may be as small as a micron or two. When an optical system, even one of very high optical quality, is used with coherent illumination, the image plane is seen to contain a number of these patterns caused by minute unavoidable glass defects (artifacts) as well as by any dust particles which may be present on the optical surfaces. The outer fringes of these numerous patterns are seen to overlap and cover virtually the entire image plane, forming an optical noise pattern which obscures fine detail in the desired image.

After the appearance of the artifact diffraction problem in the initial breadboard work, extensive measures were taken in the fabrication of the prototype elements to obtain a maximum freedom from surface defects (artifacts). However, it has since become increasingly apparent that the degree of freedom from artifacts, as well as cleanliness, which would be required to obtain even reasonable freedom from diffraction would be too great for practical consideration. It is evident that other means must be relied on for diffraction control.

Some theoretical treatment of this particle diffraction phenomenon is available (Ref. 1) but apparently nothing which treats of practical methods for their control. The control means presently incorporated in the prototype enlarger is based on the use of a rotating diffuser of special construction. Originally used on the experimental breadboard, this means is effective in dealing with the artifact diffraction problem with only slight reduction in lateral coherence. However, the loss in illumination due to this device is presently about 85%. It is expected that improvements in the diffuser and the condenser system can reduce this loss to less than 50%.

The means for controlling unwanted diffraction patterns in the use of coherent light have not yet been adequately investigated. Various promising possibilities (for example, apodizing of optical apertures) which were beyond the scope of the prototype development remain to be explored. The addition of refined methods of artifact diffraction control will help materially toward insuring optimum performance of the coherent enlarger.

Ref. 1 - B.J. Thompson - "Diffraction by Opaque and Transparent Particles" JSPIE Jan. 1964

STATEMENT OF WORK

[redacted] proposes to furnish goods and services as follows: STAT

1. Continue theoretical studies of the nature and causes of artifact diffraction patterns in coherent light, with emphasis on practical means for control.

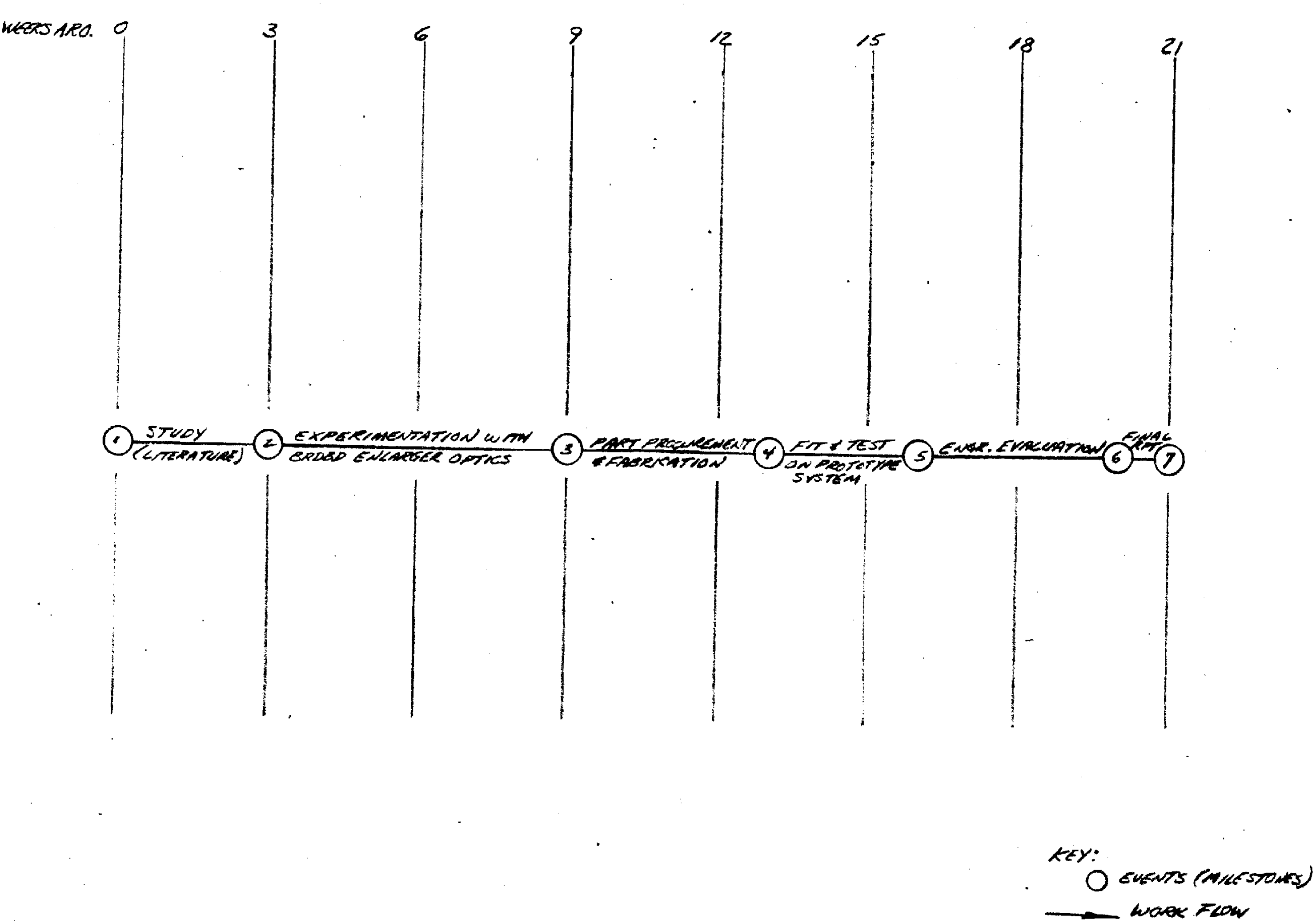
2. Perform further experimental work, using a laser source, to develop practical physical means for improved artifact diffraction control. This work will be based on theory developed under Item 1.

3. Fabricate additional components as required for improvement of a laser source with respect to artifact control, and retrofit these components to the prototype coherent enlarger recently constructed.

4. Conduct evaluation tests on the prototype enlarger with the improved source.

5. Prepare and submit an engineering report covering the theory, physical control measures and results as developed under the above items.

DIFFRACTION CONTROL



T4

PROPOSAL FOR A COHERENT SPATIAL FILTERING VIEWER

Introduction

The value of a partially coherent source of illumination in photographic reproduction processes lies in the following:

1. Virtual freedom from degradation of the modulation transfer function of the original by the reproducing optical system.

2. The possibility of spatial frequency discrimination in the reproduction by means of filtering at a transform plane.

The advantage of maintaining the transfer function in a reproducing system is well established. However, the possibilities in spatial filtering have not been extensively explored. It is known that striking effects can be obtained, particularly in the accentuation of low-contrast detail, but the practical value of spatial filtering in photo-interpretation has yet to be evaluated.

The facility for spatial filtering is, of course, included in the coherent enlarger presently under construction. However, this enlarger, being a photographic instrument, is subject to limitations with regard to rapid viewing of selected scenes, particularly where a quick experimental evaluation of the effects of varying coherence and various types of spatial filtering is desired.

For these reasons, it is felt that a direct enlarging film viewer would provide a valuable adjunct to the coherent enlarger program. It is intended in this application that film handling be limited to single frame viewing. This viewer would be of the projecting type, and for versality as well as performance considerations, the following features would be included:

1. A monochromatic source of a color suitable for visual work. A sodium vapor source appears to be a likely choice.

2. Means for varying the source coherence from approximately 75% to greater than 95%.

3. A readily actuated turret having at least four positions, for interposing selected spatial filters, and designed to permit rapid interchange of filters in the turret.

4. A film gate of approximately 2¼ + 2¼ inches, with means for providing liquid immersion when desired.

5. At least two selectable magnifications, the magnifications available to be determined after further study of the requirements.

6. A diffusing viewing screen of a type properly designed for rear projection.

The proposed viewer is intended primarily for experimental and evaluation purposes. The equipment design will be aimed at maximum simplicity consistent with the required optical performance and versatility. Considerations such as that of housing appearance, unification of controls, etc. will be definitely secondary to economy of construction, optical quality and adaptability to an experimental program.

General Description

A proposed arrangement for a coherent film viewer is shown in the attached sketch. In this scheme, the source of illumination is a sodium vapor lamp, this being chosen as having a suitable color for visual work. The sodium lamp is reimaged at a source iris by means of a condenser system, the iris being of variable apterture to permit an adjustment of the source coherence in a range of possibly 75% to 95%. A projection lens reimages the source iris at a transform plane, where the filter turret is located.

A liquid filled film gate is located in the system close to the source projection lens. The liquid gate, which is disposed horizontally for maximum convenience in film handling, consists of two high quality optical plates, the lower of which is sealed to suitably formed side walls in such manner as to form a tray-shaped vessel containing the immersion liquid.

The object plane situated in the film gate is reimaged at the viewing screen, which is composed of special screen material designed for rear projection. A suggested magnification of the object film at the screen is 8X, with the possibility of doubling this for smaller areas by the use of an auxiliary 2 power ocular, means being provided to swing the ocular out of position when not in use.

Conclusion

The equipment described will comprise an instrument specifically designed to provide the following:

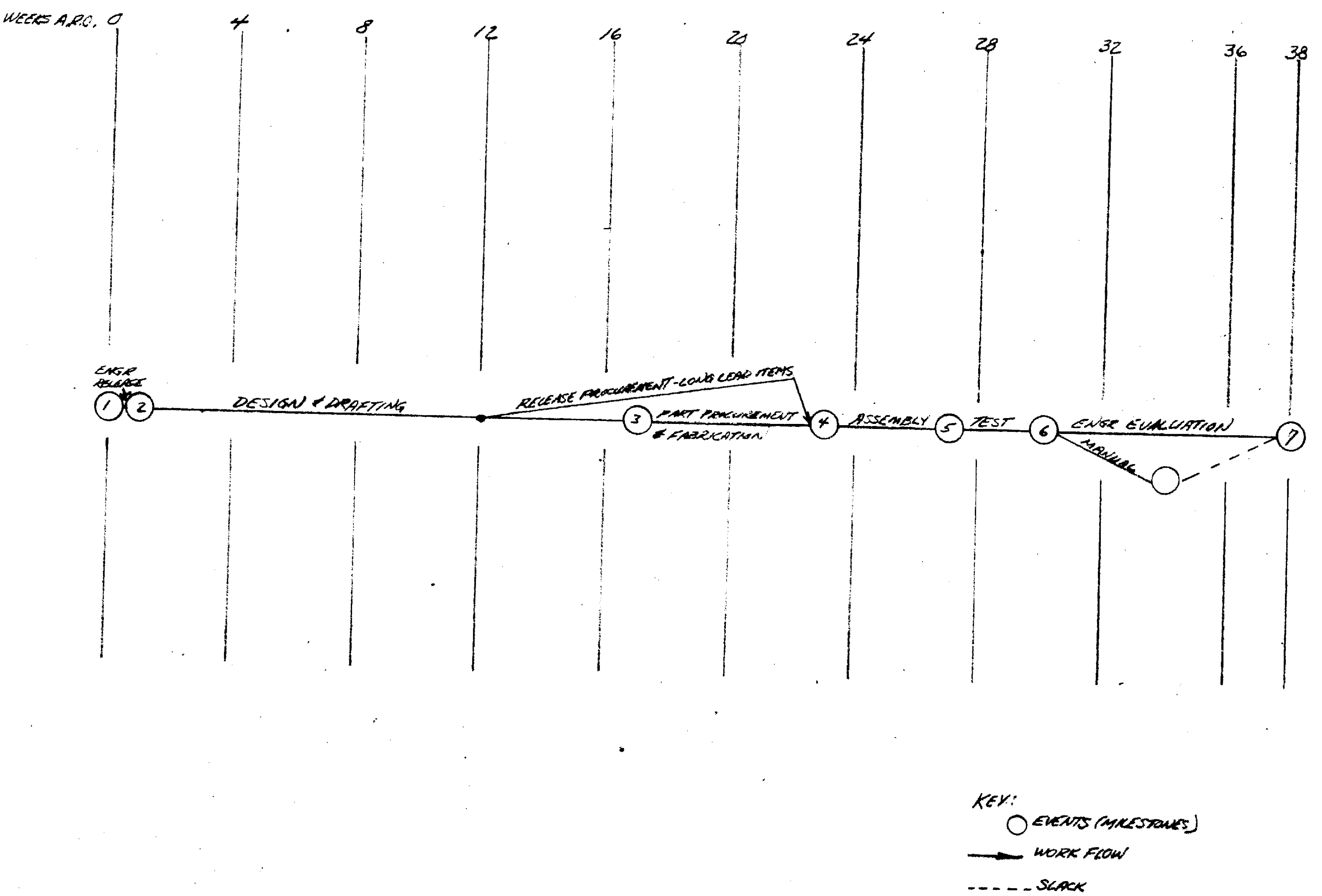
1. A convenient means of direct viewing, under enlargement, of selected film areas, substantially without loss of contrast or resolution up to a resolution limit as provided by the instrument.

2. A rapid and convenient means for evaluation of various types of spatial filtering on subject film areas selected for study.

Statement of Work

[redacted] proposes to design and fabricate STAT
one (1) prototype coherent viewer, this instrument to be of a general design and capability as described above.

COHERENT VIEWER



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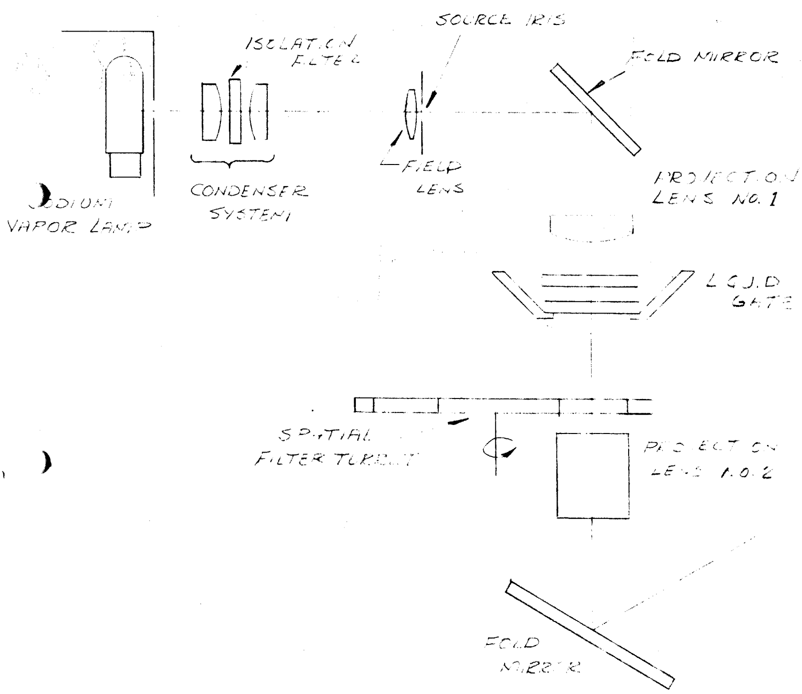

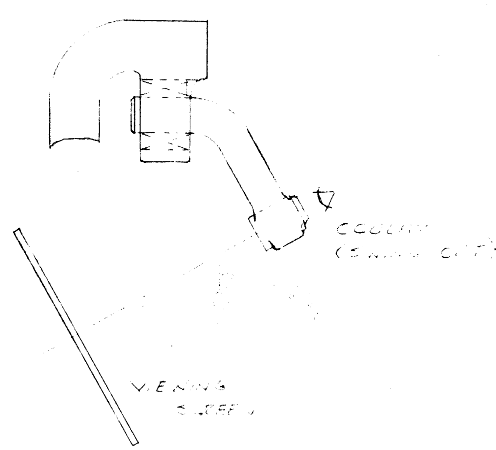

VIEWER - COHERENT
WITH SPATIAL FILTER

SCREEN SIZE 5" x 5"
MAGNIFICATION 8:1 AT SCREEN
2X SWING-OUT OCULAR
ILLUMINATION - SODIUM VAPOR LAMP
SPATIAL FILTERING - SELECTABLE
BY TURRET